



*Ktech*  
CORPORATION

- Operational efficiency

- High quality coatings

*Cold Gas-Dynamic*

- Wide spectrum of applications

*Spray Technology*

- High productivity

- Environmentally safe

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*Solid Particle Spray Process*

# Cold Gas-Dynamic Spray Technology

Cold Gas-Dynamic Spray Technology—or Cold Spray—is a rapidly emerging industrial coatings technology. Like thermal spray, Ktech Corporation's Cold Spray systems produce metal coatings for industrial needs ranging from rocket nozzles and turbine blades to electrical contacts. But—unlike thermal spray—Cold Spray technology applies metal and alloy particles at temperatures much lower than the melting temperature of either the coating or substrate. As a result, Cold Spray avoids the effects caused by high temperatures—oxidation, vaporization, melting, crystallization, residual stresses, debonding, and gas release—and reaps the benefits!

## Background

Cold spray was first demonstrated in the mid-1980s by Dr. Anatolii Papyrin and colleagues at the Institute of Theoretical and Applied Mechanics (Russian Academy of Sciences). At that time, they demonstrated a material deposition process based on the use of 1- to 50- $\mu\text{m}$  solid metal particles introduced into a gas stream accelerated to supersonic velocities. Research in the U.S. began in 1994 at the National Center for Manufacturing Sciences, which sponsored a technology demonstration program by Dr. Papyrin. In 1995, Ktech and Sandia National Laboratories (SNL) designed and installed a cold spray system at SNL to study the process, and that work continues today.

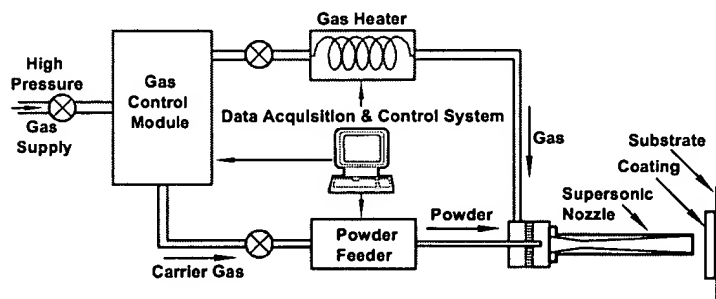
## The Process

Cold Spray is a material deposition process in which coatings are applied by exposing a metallic or dielectric substrate to a high-velocity (300 to 1200 m/s) jet of 1- to 50- $\mu\text{m}$  particles accelerated by a supersonic jet of

Operating Gases	Air, nitrogen, helium and mixtures
Stagnation Jet Pressure	100 to 500 psi
Stagnation Jet Temperature	0°C to 700°C
Gas Flow Rate	30 to 100 cfm
Powder Feed Rate	10 to 30 lbs./h
Spray Distance	0.5 to 2 inches
Power Consumption (for Heating Gas)	0 to 25 kW
Particle Size	1 to 50 $\mu\text{m}$

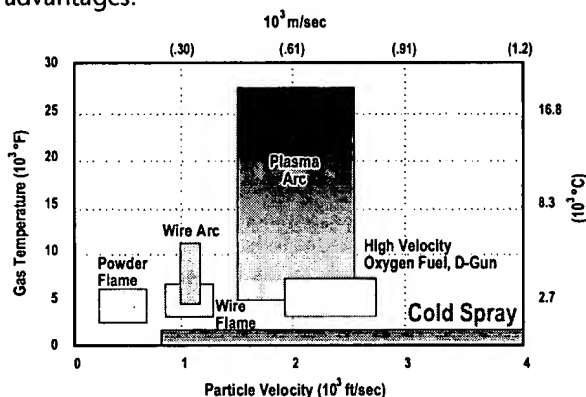
Typical Range of Jet Parameters

compressed gas. The process (see diagram below) was named "cold gas-dynamic spraying" because of the relatively low temperatures (0°C to 700°C) of the expanded gas and particle stream that emanates from the nozzle. Deposited



## Benefits of Cold Spray Technology

Where's the benefit in *cold*? When you compare Cold Spray to gas-thermal spray methods (see diagram), the distinguishing feature of Cold Spray is the ability to produce coatings with gas jet temperatures of 0°C to 700°C, a range that is lower than the melting temperature of particle materials. Eliminating the effects of high temperature on coatings and substrates offers significant advantages:



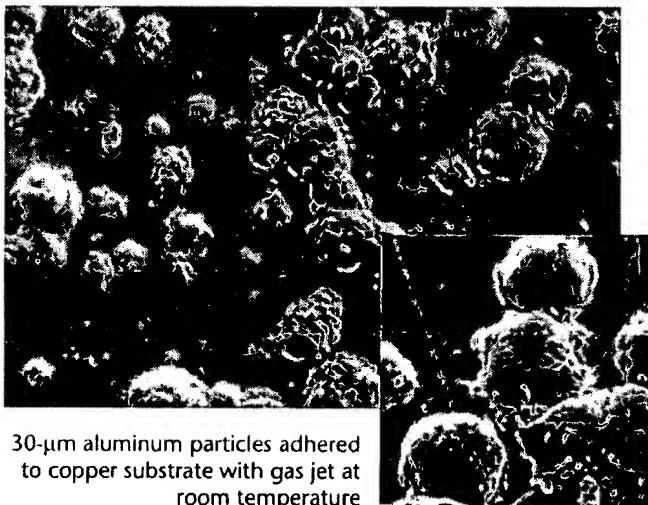
- Coating Characteristics
  - Retains properties of initial particles
  - Low oxide
  - Low residual stress level
  - High thermal/electrical conductivity
  - High density deposits
  - High hardness, cold-worked microstructure
- Coating Applications
  - As free standing structures for rapid prototyping
  - Inside surface of cylinder parts
- Deposition Capabilities
  - Thermally sensitive materials
  - Powders with a particle size < 5-10  $\mu\text{m}$
  - Highly dissimilar materials without undesirable interactions
- Operational Efficiency
  - Minimum surface preparation/masking, short standoff distance
  - High productivity due to high powder feed rate (up to 30 lbs/h)
  - High deposition rates and efficiencies for most materials
  - Collection and reuse of particles
  - No significant heating of the substrate
  - Increased operational safety because of the absence of high-temperature gas jets, radiation, and explosive gases

## *Ktech Corporation*

Dedicated to excellence in new scientific and technological solutions, Ktech Corporation is an employee-owned technology services and manufacturing company based in Albuquerque, New Mexico. Founded in 1971 as a research and engineering firm focused on the study of nuclear weapons effects, we have grown to several hundred employees and expanded our core competencies to the following areas: Technical Facilities Operations, Maintenance, and Engineering; Scientific Research and Development (including Thermal and Cold Spray); Robotics and Manufacturing; Systems Integration; Information Technologies; and Communications Media. We have provided technical support to numerous commercial, government, and international clients. Ktech has office, laboratory, fabrication, and manufacturing facilities to support any contract.

Ktech's success is primarily built on dedicated teams of experienced, creative engineers, scientists, technicians, and managers. Each member of the Ktech team is committed to helping customers find cost-effective solutions to challenging problems. In addition to winning many small business awards over the years, Ktech has been identified by the New Mexico Economic Development Department as one of the 40 fastest growing businesses in New Mexico. Our clients benefit from our ability to solve the most difficult, complex technical problems through custom engineering, accurate documentation, and a variety of professional skills.

*Cold Spray  
develops coatings or  
free standing deposits  
from particles  
in the solid state at  
relatively low temperatures.*



30- $\mu$ m aluminum particles adhered to copper substrate with gas jet at room temperature

## *Equipment and Services*

As a leader in Cold Spray applications, Ktech offers both design and production of Cold Spray systems—ranging from laboratory research and development (R&D) machines to sophisticated high-volume production machines.

Our systems are the first commercially available, computer controlled Cold Spray equipment in the United States. We also provide applications research and proof of principle testing in our Cold Spray laboratory, which allows you to validate your specific application without making a large investment in equipment and research. Ktech routinely signs non-disclosure agreements to protect each customer's intellectual property.

Because of the variety of Cold Spray's many surface engineering applications, our systems are custom configured by our engineering and systems integration staff to meet your specific applications requirements. During design, we carefully consider the unique factors of each application.

*Pre-Design Testing.* The Cold Spray process works very effectively for most metals, alloys, and composites. However, some limitations exist for hard powder materials. Therefore, each customer's application is carefully tested before design and fabrication of a Cold Spray system.

*Process Control.* Ktech is keenly aware of the importance of process control to ensure efficiency, economy, and proper quality control. Variables that must be controlled with Cold Spray systems include particle velocity, gas pressure, powder feed rate, particle and substrate temperature, and nozzle aspect angle. Our systems incorporate appropriate control solutions into each system's custom design, configuration, and component selection.

*Integration with Production Processes.* Our systems engineering staff will work closely with you to integrate a Cold Spray system into your existing production or R&D processes.

*Standard Components.* Although there is no "standard" system configuration, we offer a basic system with several options tailored to your desired production capabilities and budget. Our basic system consists of a powder hopper, gas heater, gas control module, prechamber and nozzle, and computer control and data acquisition system. We use commercially available components whenever possible and integrate these components into a turnkey system to meet your needs.

## *Applications*

Where does Cold Spray fit into your facility? Cold Spray technology can be used to produce and repair a wide range of industrial parts—for example, engine parts, turbine blades, rocket nozzles, pump parts, and others. Cold Spray's unique qualities can add immediate value to your manufacturing processes.

- Diverse coating applications
  - Strengthening/hardening
  - Wear-resistance (abrasive wear, sliding wear, fretting, cavitation)
  - Corrosion resistance
  - Magnetoconductive
  - Thermoconductive
  - High porosity (including titanium coatings for medical implants)
- Electroconductive coatings for glass, ceramics, plastics, and metals
  - Electrical conductors (printed circuit boards)
  - High current electrical contacts
  - Electromagnetic radiation shielding
  - Heated elements
  - Metallization of plastics (protection from static electricity, electrostatic painting)
- Electrical insulation (dielectric) coatings for metals, ceramics, plastics
- Joining (sealing) parts: metal-to-metal, metal-to-ceramics, ceramics-to-ceramics
- Coating forms:
  - Widths of 1 to 2 mm obtained without masking for various applications
  - Thicknesses of more than 5 to 10 mm, including
    - Dimensional restoration of worn and damaged metallic, alloy, ceramic parts
    - Production of compact powder materials
  - Direct fabrication of parts
    - Cylinder bore coatings for internal combustion engines
    - Coatings of pipes

Can your process use Cold Spray? The list of industries that can profit from Cold Spray is as diverse as its benefits:

- |                         |                            |
|-------------------------|----------------------------|
| • Aerospace             | • Textile                  |
| • Automotive            | • Pipe Production          |
| • Chemical              | • Wire Production          |
| • Oil and Gas           | • Power Generation         |
| • Agriculture           | • Construction             |
| • Electronics           | • Transportation           |
| • Paper Production      | • Tool Engineering         |
| • Metal Production      | • Food Production          |
| • Machine/Ship Building | • Research and Development |

## Basic Equipment for Cold Spray Systems

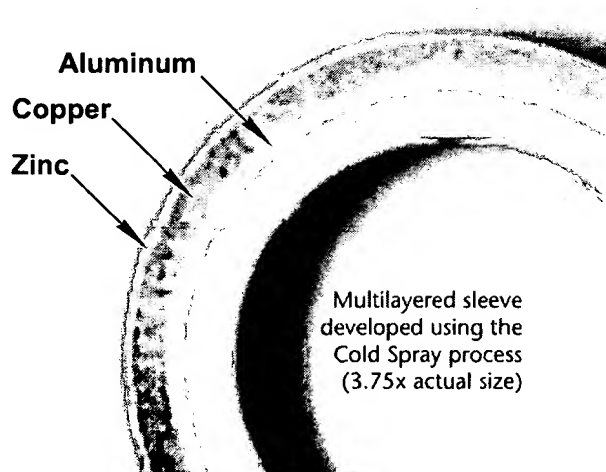
<i>Equipment</i>	<i>Description</i>
Powder Hopper	<p>Designed for processes requiring extremely high operating pressures.</p> <ul style="list-style-type: none"> <li>• Delivers continuous flow of powder to processes requiring up to 500-psi operating backpressure.</li> <li>• Large canister capacity.</li> <li>• Integrated with Ktech's data acquisition and control system.</li> </ul>
Gas Heater	<p>Tubular, resistively heated coil by single phase, 208 V, 25-kVA power supply.</p> <ul style="list-style-type: none"> <li>• Housed in thermally insulated aluminum enclosure, which can be mounted onto Cartesian X-Y system or robot end effector.</li> <li>• Capable of delivering 5-50 scfm of high-pressure gas up to 500 psi at temperatures up to 500°C.</li> <li>• Nozzle temperature controlled by data acquisition and control system.</li> </ul>
Gas Control Module	<p>Designed to provide accurate gas flow to nozzle through main gas line and carrier gas; drives powder from hopper to nozzle prechamber.</p> <ul style="list-style-type: none"> <li>• Gas flow controlled using high-pressure regulators and solenoid valves via data acquisition and control system.</li> <li>• Pressure transducers installed in both main and carrier gas lines.</li> <li>• Check valves installed for safety.</li> <li>• System installed in a powder-coated Hoffman enclosure – single inlet connection for supply gas and two exits (main and carrier gas). Enclosure configured with (a) blowout panel in case of over-pressurization and (b) fan to eliminate gas buildup inside enclosure.</li> <li>• Optional flow meters to provide precise measure of flow rate to nozzle and powder feed lines.</li> </ul>
Prechamber and Nozzle	<p>Two nozzles are provided (stainless or tool steel).</p> <ul style="list-style-type: none"> <li>• Circular geometry nozzle; rectangular geometry nozzle.</li> <li>• Designed to quickly attach to prechamber, which mounts directly to heater coil.</li> </ul>
Computer Control and Data Acquisition	<p>Consists of 500-MHz, Pentium III processor, 17-in. monitor, control and communication hardware, LabView source code, and required programming for controlling the powder hopper, gas heater, gas control module, and data logging.</p> <ul style="list-style-type: none"> <li>• Can also provide remote control of optional devices (e.g., Cartesian X-Y system, robot, dust collector, spindle motor, turntable).</li> </ul>

## Optional Equipment

Our optional equipment can give you a Cold Spray system to fit your production or R&D applications and your budget.

- Laboratory Powder Feeder
- Gas Heater, Stationary Nozzle
- Fume Hood/Spray Booth
- Sound Enclosure
- Dust Collection System
- Cartesian Position System Mounted on Rolling Frame (X-Y or X-Y-Z)
- Robot Mounted on Rolling Frame
- Spindle Motor and Tail Stock
- Motorized Variable Speed Rotating Table

Contact us for more details!



## *Working with Ktech To Build a Cold Spray System*

Ktech welcomes your inquiries about Cold Spray. When you're convinced of Cold Spray's value, our design and fabrication process will provide a system that is custom designed for you:

- First, we will meet to discuss your application, learn about your existing production or R&D processes, and outline your economic, quantity, and quality requirements. At this meeting, non-disclosure agreements are signed to protect intellectual property.
- We then conduct simple proof-of-principle tests—that is, spraying the material on samples and then testing the samples to determine if they will meet your end product requirements.
- When you are satisfied that the Cold Spray process produces the desired end product, we will quote a price for your system. After receiving a firm order, we design and fabricate the system, test it in our facilities, and then ship and install the system in your plant.
- When you purchase a system from Ktech, you receive
  - The necessary license from Dr. Papyrin.
  - Training for operators and maintenance staff.
  - Operations manuals and engineering documentation.
  - After-the-sale customer service, including spare parts and assistance via phone, e-mail, or field service engineers at the plant, as needed.
  - A limited one-year warranty on the system.

## *Intellectual Property and Licenses*

Dr. Papyrin, the holder of the patent for the cold gas spray process, was issued U.S. Patent No. 5,302,414 on April 12, 1994; European Patent No. 0484533 was issued on January 25, 1995. The claims in Dr. Papyrin's patent are very broad and were upheld in a reexamination by the U.S. Patent Office on February 25, 1997 [Reexamination Certificate (3141 th) B1 5,302,414].

Dr. Papyrin has issued an exclusive license in the U.S. to Ktech Corporation to "make and sell" cold spray equipment and non-exclusive rights to "make and sell" cold spray equipment outside of the U.S.

### *Contact Information*

If you are interested in learning more about Cold Spray or would like to discuss the potential use of this new technology for your applications, please contact

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